PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Application No.:	10/689,198
Filing Date:	October 20, 2003
Applicant:	Joseph D. Rainville et al.
Group Art Unit:	1795
Examiner:	Alix Elizabeth Echelmeyer
Title:	REGENERATIVE COMPRESSOR MOTOR CONTROL FOR A FUEL CELL POWER SYSTEM
Attorney Docket:	8450G-000213 (General Motors Docket No. GP-303508)

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Commissioner for Patents
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APPEAL BRIEF UNDER 37 CFR § 41.37

This is an appeal from the Office Action mailed May 14, 2010, in which the rejection of claims 10, 17, and 20-26 was made final. A Notice of Appeal was filed on August 4, 2010. This brief is timely filed by Monday, October 4, 2010.

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Real Party in Interest

The real party in interest is GM Global Technology Operations, Inc., which acquired the interest in an assignment recorded with the U.S. Patent and Trademark Office January 13, 2009 at Reel 22092, Frame 0737.

Related Appeals and Interferences

There are no other appeals, interferences, or judicial proceedings which will directly affect or be directly affected by or have a bearing on the Board's decision in this appeal.

Status of the Claims

Claims 10, 17, and 20-26 are pending, are rejected, and are appealed. Claims 1-9, 11-16, 18, and 19 have been cancelled.

Status of Amendments

No claims were amended after the final rejection.

Summary of Claimed Subject Matter

Claims 10 and 21 are independent claims. Claims 17 and 20 depend on claim 10; claims 22-26 depend on claim 21.

Independent Claim 10

Independent claim 10 claims a fuel cell system, comprising a fuel cell **26** that processes an oxidant to produce electrical energy

> *(page 1, lines 9-12 (beginning of ¶2]); Figure 1, showing air entering compressor, then fuel cell stack; page 4, lines 5-12 (¶18))*

and a variable capacity compressor system that supplies the oxidant to the fuel cell:

> *(Figure 2; page 2, lines 6-8 (first sentence, ¶5); page 3, lines 19-20 (¶15)).*

During operation, the variable capacity compressor system supplies the oxidant by operating in a mode selected from a normal mode below a threshold rate of 40%/s change in capacity and a rapid transient mode selected from an upward and downward variation at or above the threshold rate

> *(page 2, lines 13-16 (¶¶6,7); page 4, line 16-page 5, line 13 (¶¶19,20); page 7, lines 7-14 (first half ¶25)).*

The variable capacity compressor system comprises a compressor **14, 34** that compresses the oxidant

> *(page 2, lines 8-10 (beginning ¶5); page 3, lines 9-12 (last sentence, ¶12); Fig. 1 & page 4, lines 6-8 (in ¶18), Fig. 2),*

a compressor motor **32** that drives the compressor **14, 34**

> *(Fig. 2 & page 6, lines 21-22 (first sentence, ¶24)),*

and a controller **30** that monitors a power demand from said fuel cell and that selects a power source for the compressor motor **34**

(Fig. 2 & page 7, lines 1-19 (¶¶24, 25)).

The power source is either a main power source **22** when operating in normal mode or a supplemental power source **24** when operating in rapid transient mode which is upward

(page 2, lines 10-12 (last sentence, ¶5); page 5, lines 14-20 (¶¶21, 22); page 6, lines 7-10 (first sentence, ¶23); Fig. 1, power system 20 having main power source 22 and supplemental power source 24; Fig. 2, showing main and supplemental sources; Fig. 3, elements 301 & 304, elements 301, 302 & 308, and elements 301, 302 & 306; page 7, line 7-page 8, line 10 (¶¶ 25, 26)).

The controller also controls charging of the supplemental power source comprising regenerative braking of the motor that converts mechanical energy into charging current

(page 3, lines 1-3; page 6, lines 14-17 (in ¶23); page 7, last line-page 8, line 2; Fig. 3, elements 301& 304).

The supplemental power source is selected from capacitors and supercapacitors

(page 2, lines 17-18 (¶8); page 5, line 19-page 6, line 6 (¶22)).

Independent Claim 21

Claim 21 claims a method of operating a fuel cell system. The fuel cell system comprises a variable capacity compressor system, which in turn comprises a variable capacity compressor **14, 34** that supplies an oxidant to fuel cells of the fuel cell system while the fuel cell system operates

(page 2, lines 8-10 (beginning ¶5); page 3, lines 9-12 (last sentence, ¶12); Fig. 1 & page 4, lines 6-8 (in ¶18); Fig. 2; page 2, lines 6-8 (first sentence, ¶5); page 3, lines 19-20 (¶15))

and a compressor motor **32** that drives the compressor **14, 34**

(page 2, lines 8-10 (¶5, second sentence); Fig. 2 & page 6, lines 21-22 (¶24, first sentence)).

The method of operating the fuel cell system comprises:

operating the variable capacity compressor in a normal mode at a first capacity of the fuel cell system to produce electrical power,

(page 4, lines 5-12 (¶18); page 7, lines 7-17 (¶25));

powering the compressor motor from a main power source during said normal mode,

(page 2, lines 10-12 (¶5, last sentence); page 6, lines 7-9 (¶23, first sentence); page 8, lines 7-10; Fig. 3, elements 301, 302 & 308);

adjusting the variable capacity compressor from the first capacity to a second capacity of the fuel cell system to produce electrical power when in a rapid transient mode at or above a threshold rate of 40%/s change in capacity,

(page 2, lines 15-16 (¶7); page 5, lines 3-13 (¶20); page 7, lines 7-17 (¶25));

and, when in the rapid transient mode either:

a) powering the compressor motor from a supplemental power source when the rapid transient mode is an upward rapid transient mode

(page 2, lines 10-12 (¶5, last sentence); page 6, lines 7-10 (¶23, first sentence) page 7, lines 7-17 (¶25); page 8, lines 4-7),

or

b) regeneratively braking the compressor motor to produce charging current for said supplemental power source when operating in said rapid transient mode which is a downward rapid transient mode

(page 3, lines 1-3; page 6, lines 14-17 (in ¶23); page 7, last line-page 8, line 2; Fig. 3, elements 301& 304).

Ground of Rejection to be Reviewed on Appeal

Claims 10, 17, and 20-26 stand rejected under 35 U.S.C. § 103(a) as unpatentable over Aoyagi et al., U.S. Patent Application Publication 2002/0172847, in view of Arnold et al, U.S. Patent 6,647,724 and Lahiff, U.S. Patent Application Publication 2003/0068538.

Argument

Introduction

An examiner bears the initial burden of establishing prima facie obviousness "on the totality of the record, by a preponderance of the evidence with due consideration to the persuasiveness of argument." *Ex Parte Frye.*[1] An obviousness rejection can be overcome by showing an error in a finding of fact necessary to support the obviousness rejection or an error in the reasoning supporting the conclusion of obviousness.[2]

Here, the rejection should be reversed because any one of three key factual and legal findings is not supported by a preponderance of the evidence in the record:

(1) The evidence in the record does not support a conclusion that the prior art discloses the claim elements of *"a controller that monitors a power demand from said fuel cell and that selects a power source for said compressor motor, said power source being either a main power source when operating in said normal mode or a supplemental power source when operating in said rapid transient mode which is upward"* in claim 10 and *"powering the compressor motor from a main power source during said normal mode . . . powering the compressor motor from a supplemental power source when said rapid transient mode is an upward rapid transient mode"* in claim 21. These claim elements call for a main power source and a supplemental power source to be used in the alternative, depending on the compressor's mode.

(2) The evidence in the record does not support a conclusion that the prior art discloses the claim elements of *"said power source being . . . a supplemental power source when operating in said*

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[1] Appeal 2009-006013, slip op. at 8-9 (BPAI Feb. 26, 2010) (precedential) (quoting *In re Oetiker*, 977 F.2d 1443, 1445 (Fed. Cir. 1992) and citing and quoting *In re Piasecki*, 745 F.2d 1468, 1472 (Fed. Cir. 1984) (the initial burden of proof is on the USPTO "to produce the factual basis for its rejection of an application under sections 102 and 103").

[2] *Id.*, slip op. at 9.

rapid transient mode which is upward" in claim 10 and *"powering the compressor motor from a supplemental power source when said rapid transient mode is an upward rapid transient mode"* in claim 21. These claim elements call for a switching from one power source to an alternate power source when the threshold rate indicating rapid transient mode is attained or when normal mode is again established.

(3) The evidence in the record and the Examiner's rationale do not support a conclusion that regenerative vehicle braking in the Lahiff patent to charge Lahiff's battery would make it obvious to modify Aoyagi's compressor motor.

I. In Appellants' claims, the compressor motor uses either a main power source or a supplemental power source. In the cited Aoyagi publication the main power source and supplemental power sources are used together when more power is needed, and there is no reason, from the combination of the references, to alter the Aoyagi use.

A. Claim interpretation of the claim terms "said power source being ***either*** *a main power source . . . or a supplemental power source" and "powering the compressor motor from a main power source during said normal mode . . . powering the compressor motor from a supplemental power source when said rapid transient mode is an upward rapid transient mode"*

Claim terms are construed by how a person of ordinary skill in the art would understand the claim terms as they are used in the claims in light of the specification as a whole. *Phillips v. AWH Corporation*[3] First, the claim language itself ("either . . . or" and "powering the compressor motor from a main power source" in one mode and "from a supplemental power source" in the other mode) indicates alternative use of the main power source and the supplemental power source.

The specification also teaches alternative use, depending on the mode, as shown in Figure 3 (main power source used in box 308, supplemental power source used in box 306) and as

[3] 415 F.3d 1303, 1313 (Fed. Cir. 2005) (en banc).

described in paragraphs 5 ("A controller powers the motor from a main power source when operating in the normal mode and powers the motor from a supplemental power source when operating in the rapid transient mode."), 23 ("the compressor 14 is powered by the main power source 22 during normal operation and the supplemental power source 24 during rapid upward transient operation"), 25 ("The compressor controller 30 determines to draw power from the main power source 22 during operation in the normal mode and draws power form the supplemental power source 24 during operation in the rapid upward transient mode."), and 26 ("If the transient request is greater than the threshold, control cooperates the fuel cell system 10 in the rapid transient mode, powering the compressor motor 32 using the supplemental power source 24 in step 306 and control ends. If the transient request is not greater than the threshold, control operates the fuel cell system 10 in the normal mode, powering the compressor motor 32 using the main power source 22 in step 308 and control ends.").

The last sentence in paragraph 25 states that it is possible to draw power from both the main and supplemental power sources in an upward rapid transient, but this feature is omitted from each of the present claims.

Accordingly, if, on the totality of the record, the prior art teaches that both the main power source and the supplemental power source together power a compressor motor when a demand for increased oxidant is made, it is not obvious to operate with only the supplemental power source. Appellants believe this to be the case for the following reasons.

B. The evidence relied on by the Examiner does not disclose that these features are found in the prior art, and the proposed combination would render the Aoyagi fuel cell system inoperable for its intended purpose.

The Aoyagi patent does not describe the power source for its fuel cell's air compressor. When there is an increase in current demand from the fuel cell system, the current from the fuel cell is augmented by current from a capacitor. ¶¶9, 42-43. In general terms, then, the Aoyagi publication suggests that a second power source is used to augment a main power source.

The Arnold patent concerns a turbocharger for an internal combustion engine that is principally operated by a turbine driven by the engine exhaust. A controller operates the turbocharger when a "boost" of extra power is needed; exhaust operated the turbine, which causes the compressor to rotate and provide air from the turbocharger to the manifold to increase the air pressure over the normal pressure drawn in when the turbocharger is not in operation. Column 2, lines 53-67. The Arnold turbocharger compressor does not operate continuously, but rather operates only for "a few second or so," col. 5, ll. 64-65 and "each burst does not exceed approximately 10 seconds," col. 6. l. 2-3. The evidence of record is that "[a] turbocharger is used to increase the specific output of an IC engine by raising the manifold air pressure (MAP) and air flow into the IC engine by powering a centrifugal air compressor impeller with an expander wheel on a common shaft converting energy contained in the exhaust gas stream to shaft power." Declaration of Joseph D. Rainville Under 37 C.F.R. § 1.132, ¶5; Arnold, claim 1 ("providing stored power to an electric compressor unit for approximately three seconds or less to thereby increase intake charge pressure to the internal combustion engine"). Arnold teaches that its turbocharger compressor is powered for only a few seconds at a time, and that it depends on internal combustion engine exhaust to operate. A modification of the Aoyagi fuel cell by substituting the Arnold compressor or the Arnold method of operating its compressor thus results

in making the Aoyagi fuel cell inoperable both because a fuel cell needs a continuous supply of oxidant to operate and because the Aoyagi vehicle has an electric engine powered by its fuel cell system and so lacks the internal combustion engine exhaust necessary to operate the Arnold turbocharger compressor.

Finally, the Lahiff publication disclosure, when combined with Aoyagi and Arnold, discloses that its compressor motor 78 can receive electrical power from the fuel cell system itself or from a storage battery, ¶38 (page 3, top of right-hand column), but does not disclose alternating use of two power sources based on any criteria.

Thus, taken altogether, the evidence of record at most suggests using a supplemental power source to augment a main power source to meet increased current demand for a compressor motor.

II. The prior art does not use the different power source only during an upward rapid transient mode or provide any reason to do so.

A. Interpretation of "rapid transient mode"

Claim terms are construed by how a person of ordinary skill in the art would understand the claim terms as they are used in the claims in light of the specification as a whole. *Phillips v. AWH Corporation*[4] The specification describes compressor capacity as the rate at which the compressor supplies oxidant to the fuel cell. ¶3, lines 4-6. An upward transient response time is the time required for a change in the capacity (or oxidant supply rate). ¶4, lines 1-2. Thus, capacity is rate of supply of oxidant, or velocity of air supply, while the transients are the rates of change of capacity, the change in velocity of air supply or acceleration of air supply. See also

[4] 415 F.3d 1303, 1313 (Fed. Cir. 2005) (en banc).

¶¶6 (change from a first to a second capacity), 10 (increase in motor speed, which is acceleration) 20 (change in capacity/second). The "normal mode" can be at any capacity—whether high or low velocity of air—so long as the change in capacity is less than the 40%/s change in capacity defined as the threshold for a rapid transient mode.

On page 3 of the final Office Action, the rejection equates Arnold intermittent bursts of power to rapid transient modes upward. This is an incorrect interpretation of "upward rapid transient mode," as the Arnold burst must include both a normal mode of a certain velocity as well as the acceleration to reach that velocity, which in Arnold begins at zero velocity. The Arnold turbocharger may or may not have an upward rapid transient mode of a threshold rate of 40%/s change in capacity or higher on its way up to the capacity at which it operates during the burst of power.

On page 6 of the final Office Action the Examiner argues "the skilled artisan will recognize that the additional power sources would provide more power for those motor speed changes, resulting in the rapid transient modes of the instant invention." The claims, however, do not pile on additional power sources, but alternate between a main power source and a supplemental power source. Hence, the rationale to simply add more power sources does not result in what Appellant claim.

B. The evidence relied on by the Examiner does not disclose a different power source only during an upward rapid transient mode. The Arnold "intermittent bursts" provide power from the same power source also during normal (but higher capacity) mode.

The Aoyagi patent does not disclose a power source for its compressor supplying fuel cell oxidant. The Arnold patent describes a turbocharger for an IC engine that is only operated for only "a few second or so," col. 5, ll. 64-65 and "each burst does not exceed approximately 10 seconds," col. 6. l. 2-3 or "providing stored power to an electric compressor unit for approximately three seconds or less to thereby increase intake charge pressure to the internal combustion engine," claim 1. In column 6, the Arnold reference teaches examples "wherein each burst does not exceed approximately 10 seconds." In this kind of use, "[a]n exemplary method may include start-up through use of stored power (e.g., capacitor and/or battery) followed by use of on-line power from a turbine generator. In such an exemplary method, stored power is used for only a few seconds (e.g., approximately 2 seconds to approximately 3 seconds). Consider an exemplary method that includes discharging one or more capacitors to power an electric compressor unit for approximately 3 seconds and switching to on-line power from a [sic] electric turbine unit operating as a generator, or, alternatively, switching to another capacitor or group of capacitors." Thus, at most, the Arnold reference teaches that a switch to a different power source evidence of record, nothing in the prior art relates the time interval of the Arnold capacitor use to an interval of an upward a rapid transient mode. Certainly, it is not inherent in the Arnold patent that the 2-3 seconds use of a capacitor represents a rapid transient mode at or above a threshold rate of 40%/s change in capacity, as inherency requires that the

element is '"necessarily present," not merely probably or possibly present, in the prior art. Trintec Industries, Inc. v. Top-U.S.A. Corporation[5].

The rejection is based on a rationale (from page 3 of the final Office Action) that "[i]t would have been desirable to use the compressor of Arnold et al. in the system of Aoyagi et al. since the rapid transient modes of Arnold et al. would provide greater bursts of air to the fuel cell system when more power from the fuel cell is needed." This reasoning is incorrect because a substitution of the Arnold compressor, which operates only to provide intermittent bursts, would render the Aoyagi fuel cell inoperable for its intended purpose of operating a motor vehicle, which must have long periods of continual current. In addition, the Arnold compressor relies on power generated by a turbine turned with exhaust from an internal combustion engine, which is not present in the Aoyagi system. Thus, again, the substitution into the Aoyagi system would result in an inoperable system. The proposed combination fails to suggest all of the claim elements as arranged in Appellants' fuel cell system or to provide all of the method steps as combined in Appellants' inventive method.

The rejection is also based on a rationale (from page 4 of the final Office Action) that "[i]t would have been obvious . . . to determine rate at which air should be provided to the fuel cell of Aoyagi et al., using the compressor of Arnold et al. to control the rate, since controlling the air controls the electrical output of the fuel cell. It has been held that discovering an optimum value of a result effective variable involves only routine skill in the art." This reasoning fails to appreciate the distinction between compressor capacity, which is the rate the compressor supplies air and which is what the Examiner describes in this passage, and the rapid

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[5] 295 F.3d 1292, 1295 (Fed. Cir. 2002) (quoting In re Robertson, 169 F.3d 743, 745 (Fed. Cir. 1999)).

transient modes of Appellants' claims, which is the rate of change of the rate of supplying air. Aoyagi's controller already determines the rate at which air should be provided to the fuel cell, and needs no modification. See Aoyagi ¶¶33-34. Analogously to Arnold's "intermittent bursts," the Aoyagi patent uses a capacitor to supply power to its electric engine in tandem with its fuel cell system to meet higher demand. One cannot substitute in the Arnold turbocharger for the Aoyagi capacitor, however, since the Aoyagi electric engine does not use air directly.

Moreover, there is no reason from the prior art systems to base a change in power sources on any particular rate of change of compressor capacity. Before it is routine of optimize a variable, the effect of the variable must be understood. The references used in rejection do not recognize this variable or relate it to a change in a power source. The Examiner says on page 5 of the final Office Action that the Arnold patent teaches selection of a power source based on demand to the compressor, but this is but a conclusory statement without support in the reference itself. The Examiner further states that "[In the combination of the compressor system of Arnold et al. and the compressor system of Aoyagi et al., or the substitution of the compressor system of Arnold et al., for the compressor system of Aoyagi et al., this limitation is inherent. The compressor system of Arnold et al. requires the two power sources to provide the necessary power boosts." With respect it is insufficient for obviousness the claims at hand that there be two power sources, as there must also be a controller that selects from the power sources based on whether operation is in a rapid transient mode or normal mode (fuel cell system claims) or the fuel cell must be operated so that the compressor is powered by the one or the other power source depending on whether it is operating in a rapid transient mode or normal mode (method claims). The Arnold patent may use two power sources, but it doesn't use them in the way set out in Appellants' claims.

Additionally, for the reasons already discussed, the person of ordinary skill in the art would not substitute a turbocharger for an internal combustion engine in place of the Aoyagi compressor system.

III. Lahiff's regenerative vehicle braking is not similar to Appellants' claim feature of regenerative braking the compressor motor; the devices are not similar; the similar device in Lahiff, Lahiff's compressor motor, is not modified in this way. Thus, there is no reason to modify the Aoyagi fuel cell power supply as the Examiner proposes because only Appellants, and not the prior art, teaches such a modification.

A. Evidence of record on this issue

The Declaration of Joseph D. Rainville Under 37 C.F.R. § 1.132, ¶3, discusses the Lahiff vehicle system:

> The Lahiff application teaches to operate a fuel cell system's electric motor-powered air compressor in a very inefficient manner to dissipate or waste excess electrical power generated by an electric vehicle's regenerative braking system. Electric vehicles typically have the ability to reverse the direction of energy flow in the vehicle's main drive or traction motor. Normally the main drive or traction motor converts electric power into mechanical torque to accelerate the vehicle. During vehicle braking or slowing conditions, the motor can reverse that process to convert mechanical torque to electric power that is typically stored in an on board battery or other electrical storage device. This is done to make the vehicle more energy efficient. Lahiff teaches that when more electrical energy is produced by this method than can be stored on board the vehicle this excess power is sent to the on board fuel cell's air compressor to be converted to mechanical energy as air pressure and flow. This air flow is dumped overboard using a system of valves bypasses the fuel cell stack. Alternately, Lahiff also teaches that if the minimum power request from the vehicle is lower than the minimum power that can be produced by the fuel cell system, the vehicle dissipates the excess power by sending to the air compressor, converting it into air pressure and flow that it vents overboard. Lahiff does not teach or imply any mechanism to reclaim mechanical energy of the spinning compressor as our invention does. Only our invention reclaims this energy by regeneratively controlling the compressor motor of a fuel cell system to allow the reclaimed mechanical energy converted to electrical energy to be available to the compressor for the next increase in RPM or speed. Lahiff only teaches to run the compressor in an inefficient manner to waste energy, not to conserve it.

Paragraph 5 adds:

> . . . The Lahiff application does not state or imply using the compressor-motor unit to create or store electrical energy, only to dissipate excess electrical energy by converting it to air flow and pressure in the air compressor to then vent this flow and pressure overboard.
>
> The Examiner's statement on page 6 of the office communication dated 2/18/2009 that "So, the compressor of Lahiff et al. is certainly used to generate electricity as well as dissipate it" is not accurate. The Examiner then directs us to see the second sentence of [0011] of the Lahiff application. To quote the first three sentences of paragraph [0011] of Lahiff for context, Lahiff says, "According to one embodiment of the present invention, a method for dissipating electrical power output in a fuel cell power system is disclosed. The fuel cell power system includes a fuel cell stack for generating electric power and a compressor for delivering gas containing oxygen to the fuel cell stack. The method includes the steps of determining an amount of electrical power to be dissipated, operating the compressor to draw electrical current as required to dissipate the power, and valving the compressor to reduce the delivery of gas containing oxygen to the fuel cell stack." I see no teaching or reference to the compressor being used to create or return electrical power to the system, only to consume it. In the Lahiff fuel cell system, electric power is generated with either the vehicle regenerative braking system, or the fuel cell stack generates electric power, and that is by the chemical reaction of oxidant and fuel, not by regenerative control of the compressor motor to convert mechanical energy into electricity.

B. The Lahiff publication does not teach to conserve the energy of its compressor, but rather to use its compressor to dissipate, or waste energy. Moreover, the method by which the Lahiff vehicle is regeneratively braked is inapplicable to a compressor motor; a compressor motor is not a device similar to a vehicle with brakes. At most, a combination of Lahiff's regenerative braking would make obvious regenerative braking of the Aoyagi vehicle to charge its battery; this does not result in Appellants' claimed fuel cell system or method.

The combined references provide no reason to modify the Aoyagi system to maintain a supplemental power source at least in part by recapturing energy from the very compressor that it powers in an upward rapid transient mode. In Aoyagi, the capacitor is connected in parallel with the fuel cell and is charged by the fuel cell. The Lahiff publication uses its fuel cell compressor to dissipate ("waste") excess electrical power, as described in the passages above from Mr. Rainville's Declaration.

The Lahiff dissipation of energy is the opposite of Appellants'' intentional energy conservation in recovering energy from the fuel cell compressor. The Lahiff publication teaches away from Appellants' invention, and thus does not make Appellants' invention obvious. "A reference may be said to teach away when a person of ordinary skill, upon reading the reference, would be discouraged from following the path set out in the reference, *or would be led in a direction divergent from the path that was taken by the Appellant.*" *Ricoh Co., Ltd. v. Quanta Computer Inc.*[6] The skilled artisan would simply not turn to the Lahiff publication in the first place for a method of conserving the energy of the system; there would be no expectation of a successful modification based on Lahiff's intentional energy dissipation.

The Examiner argues that one would use the known technique of the Lahiff regenerative braking to improve a similar device to brake the Lahiff compressor motor. First, Lahiff teaches a different use for its compressor motor, that of *dissipating,* not conserving energy. Second, as Mr. Rainville describes, "During vehicle braking or slowing conditions, the motor can reverse that process to convert mechanical torque to electric power that is typically stored in an on board battery or other electrical storage device. This is done to make the vehicle more energy efficient. Lahiff teaches that when more electrical energy is produced by this method than can be stored on board the vehicle this excess power is sent to the on board fuel cell's air compressor to be converted to mechanical energy as air pressure and flow. This air flow is dumped overboard

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[6] 550 F.3d 1325, 1332 (Fed. Cir. 2008) (quoting *In re Kahn*, 441 F.3d 977, 990 (Fed. Cir. 2006)) (emphasis added). The Board is referred also to *Ex parte Jellá*, 2008-1619 (BPAI 2008) (precedential) which states the law in this way: "'A reference may be said to teach away when a person of ordinary skill, upon reading the reference, . . . would be led in a direction divergent from the path that was taken by the applicant.' *In re Haruna*, 249 F.3d 1327, 1335 (Fed. Cir. 2001) (quoting *Tec Air, Inc. v. Denso Mfg. Mich. Inc.*, 192 F.3d 1353, 1360 (Fed. Cir. 1999))."

using a system of valves bypasses the fuel cell stack." Thus, the devices (vehicle, air compressor motor) are not similar in Lahiff, nor are they similarly used. If anything, a modification of the Aoyagi system according to Lahiff would result in addition of regenerative braking of Aoyagi's vehicle coupled with the Lahiff energy dissipation system involving the air compressor. It would not result in Appellants' invention.

Still yet, nothing in the combined references teaches using the same supplemental power source charged by regeneratively braking the compressor to power the compressor in a rapid upward transient mode.

Conclusion

Accordingly, Appellant respectfully requests that the Board reverse the rejection of claims 10, 17, and 20-26.

Should communication by telephone be needed or helpful, the undersigned can be reached at (248) 641-1220 (direct line).

Respectfully submitted,

Dated: September 30, 2010

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Claims Appendix

10. A fuel cell system, comprising:

a fuel cell that processes an oxidant to produce electrical energy;

a variable capacity compressor system that supplies said oxidant to said fuel cell and that during operation of the fuel cell system, supplies said oxidant by operating in a mode selected from a normal mode below a threshold rate of 40%/s change in capacity and a rapid transient mode selected from an upward and downward variation at or above the threshold rate, said variable capacity compressor system comprising:

a compressor that compresses said oxidant; and

a compressor motor that drives said compressor

a controller that monitors a power demand from said fuel cell and that selects a power source for said compressor motor, said power source being either a main power source when operating in said normal mode or a supplemental power source when operating in said rapid transient mode which is upward wherein said supplemental power source is selected from capacitors and supercapacitors and wherein said controller controls charging of said supplemental power source comprising regenerative braking of the motor that converts mechanical energy into charging current.

17. The fuel cell system of claim 10 wherein charging further comprises using power generated by said fuel cell.

20. The fuel cell system of claim 10 wherein said controller shifts said variable capacity compressor between said normal mode and said rapid transient mode based on said power demand.

21. A method of operating a fuel cell system comprising a variable capacity compressor system, comprising a variable capacity compressor that supplies an oxidant to fuel cells of the fuel cell system while the fuel cell system operates and a compressor motor that drives the compressor, the method comprising:

operating said variable capacity compressor in a normal mode at a first capacity of the fuel cell system to produce electrical power;

powering the compressor motor from a main power source during said normal mode;

adjusting said variable capacity compressor from said first capacity to a second capacity of the fuel cell system to produce electrical power when in a rapid transient mode at or above a threshold rate of 40%/s change in capacity; and

when in said rapid transient mode either:

a) powering the compressor motor from a supplemental power source when said rapid transient mode is an upward rapid transient mode, or

b) regeneratively braking the compressor motor to produce charging current for said supplemental power source when operating in said rapid transient mode which is a downward rapid transient mode.

22. The method of claim 21 wherein said second capacity is greater than said first capacity when operating in said upward rapid transient mode.

23. The method of claim 21 wherein said second capacity is less than said first capacity wherein operating in said downward rapid transient mode.

24. The method of claim 21 wherein said supplemental power source is a capacitor.

25. The method of claim 21 further comprising charging said supplemental power source during said normal mode.

26. The method of claim 21 further comprising using power from said supplemental power source to increase speed of the compressor motor when in said upward rapid transient mode.

Evidence Appendix

Declaration of Joseph D. Rainville Under 37 C.F.R. § 1.132, entered with Request for Continued Examination and Submission Under 37 C.F.R. § 1.114 submitted April 22, 2009.

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.:	10/689,198
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Applicant:	Joseph D. Rainville et al.
Group Art Unit:	1795
Examiner:	Alix Elizabeth Echelmeyer
Title:	REGENERATIVE COMPRESSOR MOTOR CONTROL FOR A FUEL CELL POWER SYSTEM
Attorney Docket:	8450G-000213 (General Motors Docket No. GP-303508)

Commissioner for Patents
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Declaration of Joseph D. Rainville Under 37 C.F.R. § 1.132

I, Joseph D. Rainville, declare:

1. I am the first inventor named in this patent application. I have been a practicing Hydrogen Fuel Cell Engineer since October 21st of 1996. I graduated from Rochester Institute of Technology in 1994 with a BS degree in Mechanical Engineering Technology. I continued my education with air compressors and turbomachinery by enrolling in the "Fluid Mechanics of Turbomachines" class at Rochester Institute of Technology in 2002, in addition to a graduate level class in "Centrifugal Compressor Design and Performance" taught by Dr. David Japikse at Concepts NREC (Northern Research and Engineering Corp) of White River Junction, VT. I am

an inventor of four issued patents and fourteen patent applications in the field of Fuel Cells. I am also an author and inventor of 13 publications describing unpatented inventions.

2. I have read and understood Lahiff, U.S. Patent Application Publication No. US 2003/0068538 A1 and Arnold et al., U.S. Patent No. 6,647,724. I understand and am familiar with the technology described in each of these two documents. While there are a few superficial similarities to my invention, the technologies described in the Lahiff and Arnold documents differ significantly in scope and spirit from my invention.

3. The Lahiff application teaches to operate a fuel cell system's electric motor-powered air compressor in a very inefficient manner to dissipate or waste excess electrical power generated by an electric vehicle's regenerative braking system. Electric vehicles typically have the ability to reverse the direction of energy flow in the vehicle's main drive or traction motor. Normally the main drive or traction motor converts electric power into mechanical torque to accelerate the vehicle. During vehicle braking or slowing conditions, the motor can reverse that process to convert mechanical torque to electric power that is typically stored in an on board battery or other electrical storage device. This is done to make the vehicle more energy efficient. Lahiff teaches that when more electrical energy is produced by this method than can be stored on board the vehicle this excess power is sent to the on board fuel cell's air compressor to be converted to mechanical energy as air pressure and flow. This air flow is dumped overboard using a system of valves bypasses the fuel cell stack. Alternately, Lahiff also teaches that if the minimum power request from the vehicle is lower than the minimum power that can be produced by the fuel cell system, the vehicle dissipates the excess power by sending to the air compressor, converting it

into air pressure and flow that it vents overboard. Lahiff does not teach or imply any mechanism to reclaim mechanical energy of the spinning compressor as our invention does. Only our invention reclaims this energy by regeneratively controlling the compressor motor of a fuel cell system to allow the reclaimed mechanical energy converted to electrical energy to be available to the compressor for the next increase in RPM or speed. Lahiff only teaches to run the compressor in an inefficient manner to waste energy, not to conserve it.

4. To quote the first line of the Lahiff abstract: "A method and apparatus for *dissipating energy* in a fuel cell generator system is provided." (Emphasis added.) The Lahiff application does not state or imply using the compressor-motor unit to create or store electrical energy, only to dissipate excess electrical energy by converting it to air flow and pressure in the air compressor to then vent this flow and pressure overboard.

The Examiner's statement on page 6 of the office communication dated 2/18/2009 that "So, the compressor of Lahiff et al. is certainly used to generate electricity as well as dissipate it" is not accurate. The Examiner then directs us to see the second sentence of [0011] of the Lahiff application. To quote the first three sentences of paragraph [0011] of Lahiff for context, Lahiff says, "According to one embodiment of the present invention, a method for dissipating electrical power output in a fuel cell power system is disclosed. The fuel cell power system includes a fuel cell stack for generating electric power and a compressor for delivering gas containing oxygen to the fuel cell stack. The method includes the steps of determining an amount of electrical power to be dissipated, operating the compressor to draw electrical current as required to dissipate the power, and valving the compressor to reduce the delivery of gas containing oxygen to the fuel cell stack." I see no teaching or reference to the compressor being used to create or return

electrical power to the system, only to consume it. In the Lahiff fuel cell system, electric power is generated with either the vehicle regenerative braking system, or the fuel cell stack generates electric power, and that is by the chemical reaction of oxidant and fuel, not by regenerative control of the compressor motor to convert mechanical energy into electricity.

5. Arnold teaches to separate a typical 'turbocharger' component into two distinct halves, no longer connected by a common shaft as done on a typical turbocharged internal combustion (IC) application. A turbocharger is used to increase the specific output of an IC engine by raising the manifold air pressure (MAP) and air flow into the IC engine by powering a centrifugal air compressor impeller with an expander wheel on a common shaft converting energy contained in the exhaust gas stream to shaft power. Simply put, "more air + more fuel = more power" as shown in Fig. 7 of the Arnold Patent.

Arnold removes the common shaft between the compressor and expander wheels and replaces them with an electric motor to power the compressor and an electric generator powered by the turbine. Noting line 20 in column 4 of the Arnold Patent, it appears the added mass and complexity of the system is designed to provide instant 'boost' to an IC engine, overcoming the common 'turbo lag' issue of a typical turbocharger. Turbo lag refers to the time it takes for the turbo to 'spool up' and make boost relative to when the driver steps on the accelerator pedal.

To quote the Arnold Patent column 1, first paragraph "Subject matter disclosed herein relates generally to methods, devices, and/or systems for enhancing engine performance through use of an electrically driven compressor and/or turbine generator." The Arnold patent does not teach or imply to use an electrically driven compressor to convert mechanical energy into electrical energy.

6. The examiner makes several references on pages 6 and 7 of the Office communication dated 2/18/2009 to variable speed compressors and the teachings of Arnold in combination with, and in view of Lahiff. Every variable power or load following fuel cell system would have a variable electrical output, requiring a varying amount of oxidant air, hence variable speed compressor. Arnold's electrically driven variable speed compressor replaces a mechanically driven variable speed compressor. All turbocharged IC engines would have a variable speed compressor, whether powered by an exhaust driven turbine or a shaft or belt drive system from the IC engines crankshaft.

7. Any typical state-of-the-art fuel cell system uses a variable speed electric motor-driven air compressor to provide oxidant air to the fuel cell stack. It is unique to my invention to use that same component to capture the mechanical inertia of reducing its rpm, in response to lowering the power output level of the fuel cell, as electrical power so that this power can be available for the next increase in rpm corresponding to requesting an increase the electrical output of the fuel cell system.

The electric motor driven air compressor that supplies oxidant to a fuel cell stack should generally respond a load change request with an upward transient response time of 10-90% power in approximately 1-second. Therefore, the compressor must respond in similar fashion to supply the required oxidant for the power requested. This rapid response time can cause a short-term power drain several times the compressor motor's rated power. In addition, power is wasted when current is used to brake the motor on a down transient. My invention combats the power drain and assists with transient responses with an energy storage device (such as a

capacitor) and a control circuit added to the compressor motor controller to store braking energy during downward power transients, and release that energy to assist with the upward transients. This control scheme presents several advantages including faster system response and lower power drains on upward power transients. The capacitor can also be charged slowly under normal system operating conditions to keep it fully charged.

I do not find this invention to be obvious in reference to regeneratively braking a vehicle. This invention is used not to reclaim mechanical energy normally wasted by vehicular friction brakes. This invention is reclaiming the rotational energy of a motor driven air compressor to be stored in the compressor motor controlled to be used to increase the response time of the compressor at the next acceleration request. This also reduces the parasitic load of the compressor on the fuel cell stack, allowing the stack power to not be 'pulled down' by the compressor power request when the stack is concurrently creating electrical power to propel the electric vehicle it is contained in. Lahiff's regenerative vehicle braking does not, and cannot, have these features. Nor does Lahiff teach or suggest such features with his fuel cell system compressor.

9. I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true. I understand that willful false statements and the like if made herein would be punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and may jeopardize the validity of the application or any patent issuing there from.

Joseph D. Rainville

Date: 16-APR-2009

Related Proceedings Appendix

None